Sweet Sorghum: a smart solution for bioethanol production?

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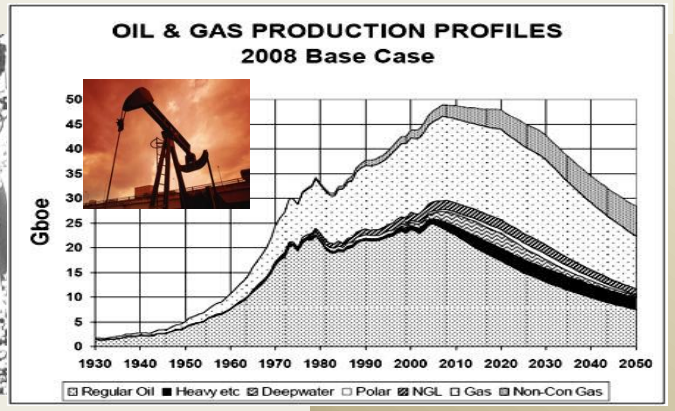
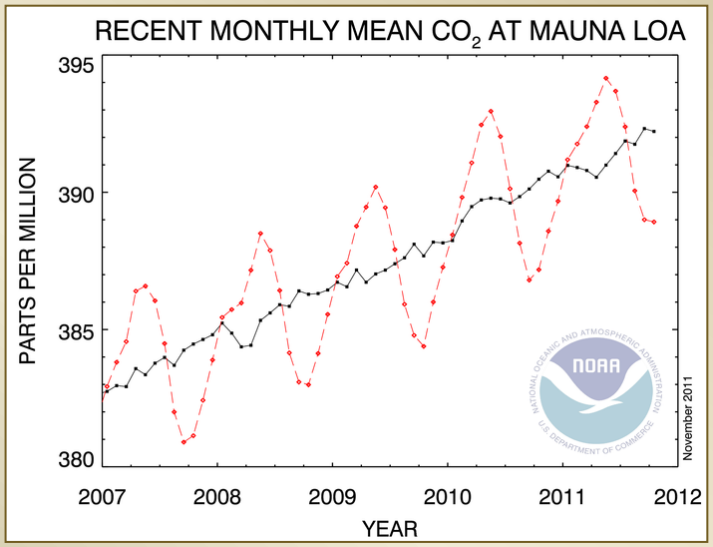
Context

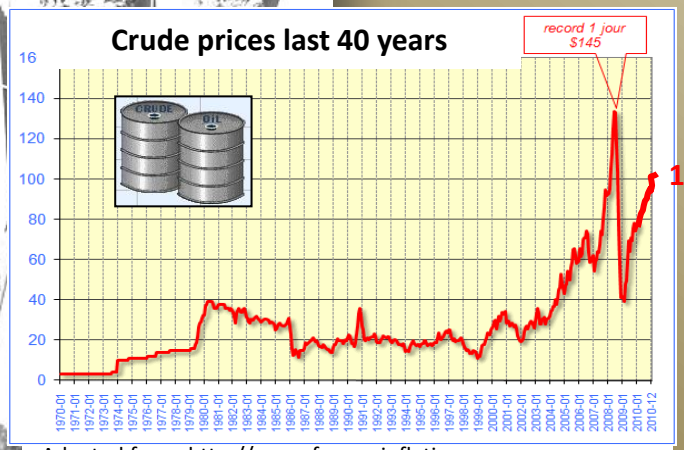
Global oil production is rapidly approaching its peak



http://www.oildecline.com/



CO_2 atmospheric concentration in Oct. 2011 = **388.92 ppm**
http://www.esrl.noaa.gov



Adapted from http://www.france-inflation.com

It is urgent to find alternative and sustainable energies

Biofuels or agrofuels, defined as solid, liquid or gas fuels derived from biomass, are today the only direct subsitute for oil on a significant scale particularly in the transport sector

Context

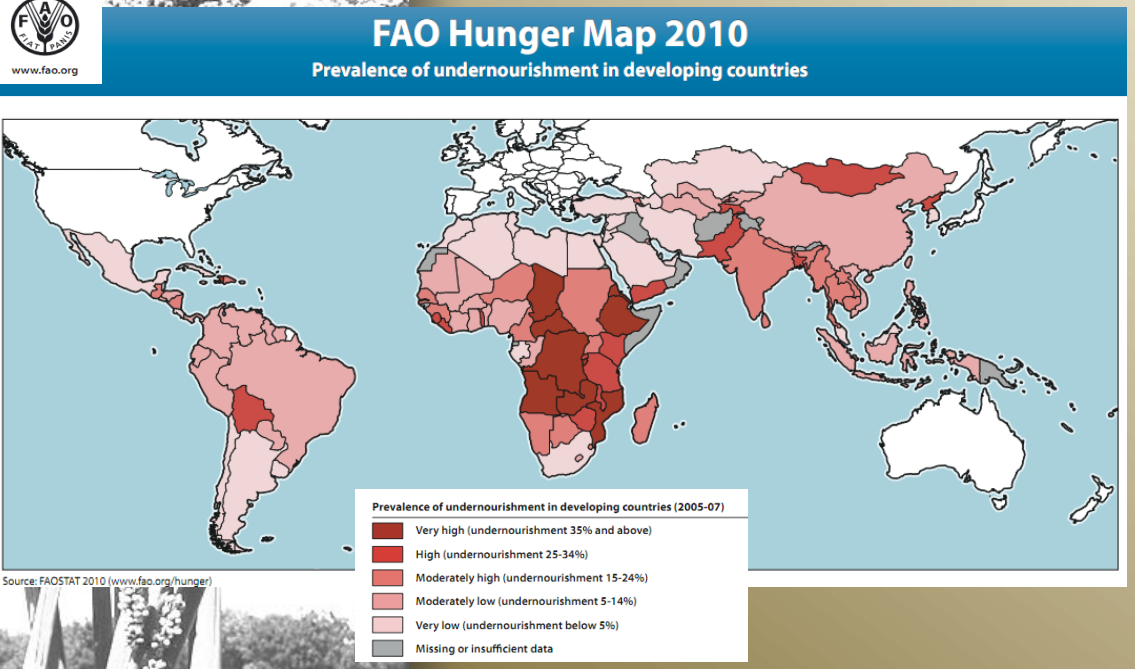
poorest countries will be lead to grow biofuel crops

Less arable surfaces available for food production

Increasing staple food world market prices
(good for producers, bad for urban consumers)

Instability of the staple food market

Increase of food insecurity



Why sorghum for producing ethanol ?

Tropical zone

VS

Propagation
Cuttings seeds

Length of cycle
12-16 months 4-5 months

Water requirements
36 000 m3 12000 m3

Adaptation to dry zones
Irrigation yes

Adaptation to marginal soils
cane < < sorghum

Grain production
0 << up to 6T / ha (2 cycles)

Ethanol production (l ha-1)
6500 5600 (2 cycles)

Uses
Sugar, Fuel Food, Feed, Fuel

Temperate zone

VS

Intrant needs
sorghum < < maize

Water requirement
1/3 less than maize

Nitrogen Use Efficiency
sorghum > > maize

Adaptation to dry environments
sorghum > > maize
(stay green)

Adaptation to marginal soils
sorghum > > maize

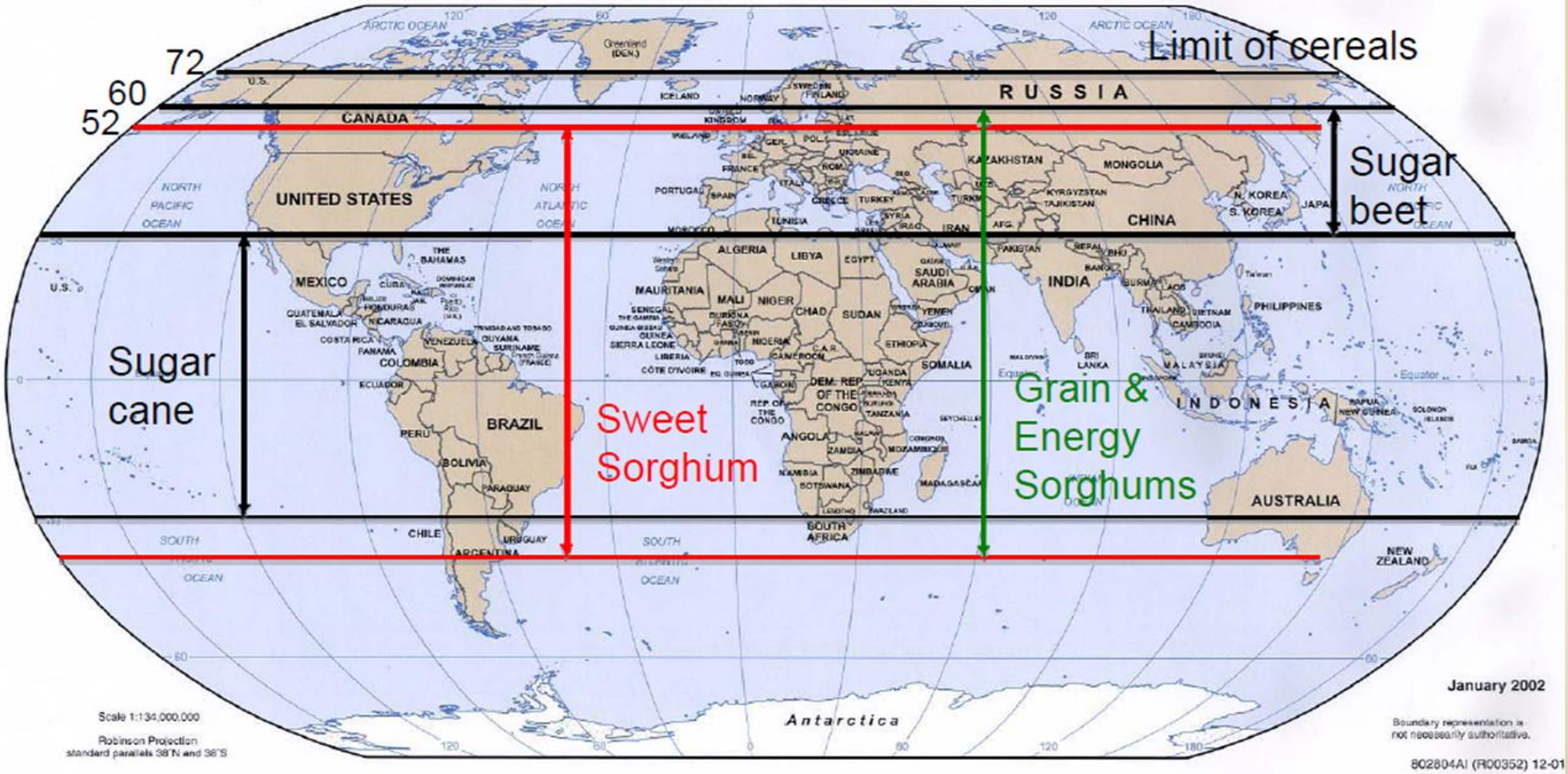
Biomass
sorghum ⇔ maize
(25 to 40T DM ha-1)

ADVANTAGE SORGHUM

Hudge potential of improvement and adaptation
Respect of environment
Development of rural zones
Low competition with food crop
Better sustainability of the production system

Why sorghum for producing ethanol ?

The Adaptability of Sorghum



What sorghum for what biofuel ?

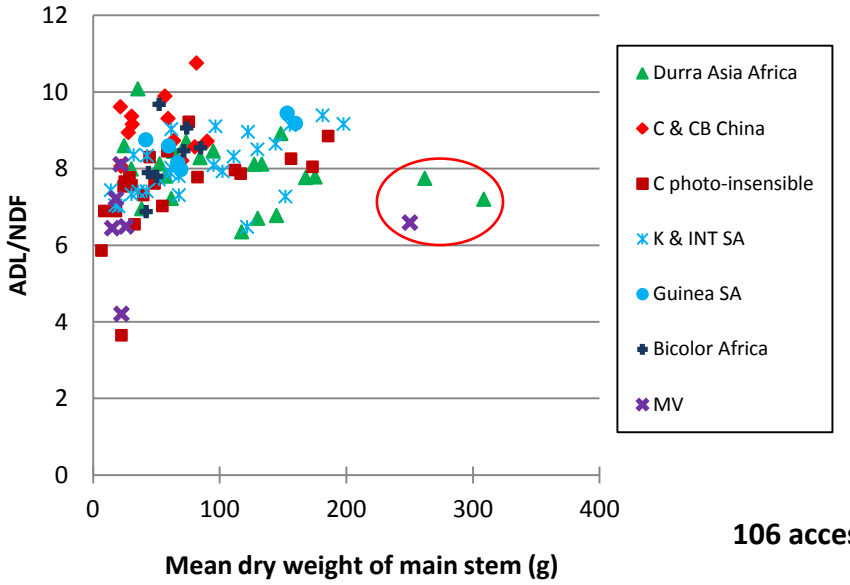
1 **2nd generation EtOH** or **methane production :** a **biomass sorghum** with the following traits:

- ✓ **High biomass** production (30-40 TDM ha $^{-1}$) which means a plant height > 3.5-4m and a long cycle (4-5 months)
- ✓ a photosensitivity adapted to induce flowering by the end of August
- ✓ a **good quality** of the raw material which must be poor in lignin (*bmr* trait) to increase **digestibility** of the tissues
- ✓ a good tolerance to lodging (antagonistic with *bmr* trait)
- ✓ tolerance to water deficit / high water use efficiency

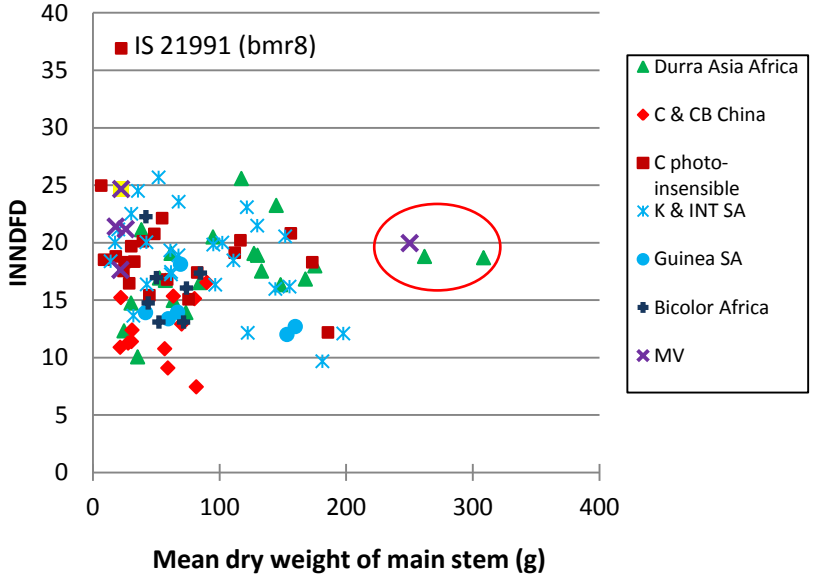
for that purpose, grain production is not essential

What sorghum for what biofuel ?

2nd generation EtOH or methane production : a biomass sorghum



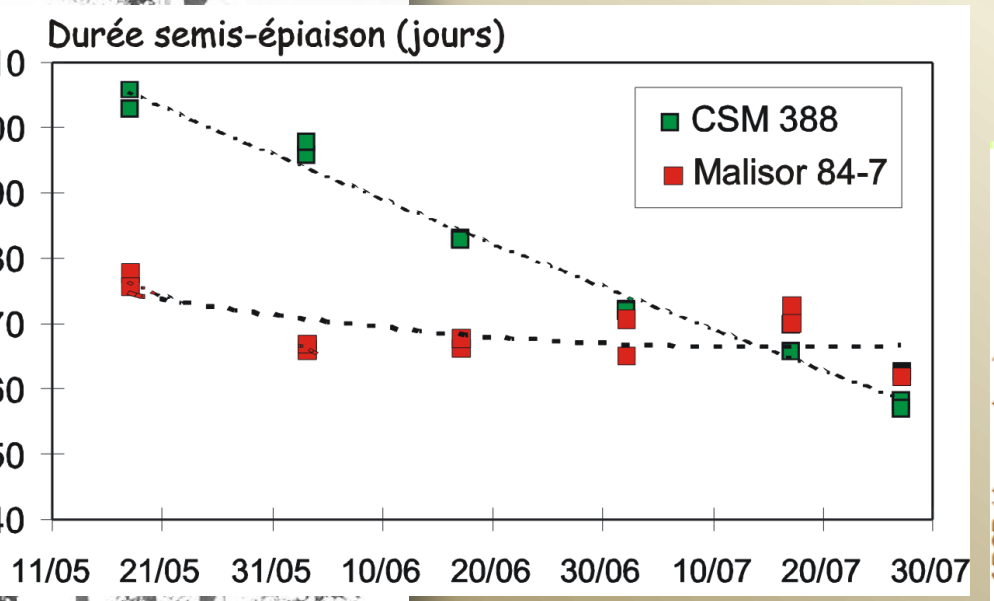
106 accessions



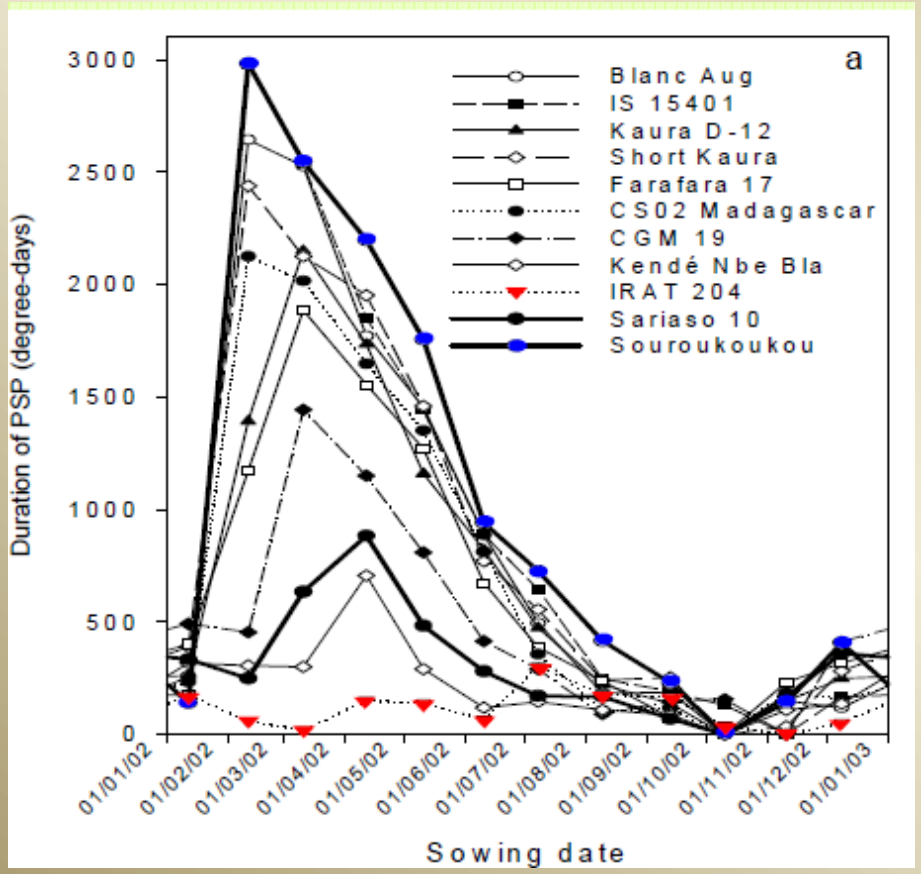
Possible combination of
+ high stalk biomass
+ low lignin content
+ good digestility of fibres

What sorghum for what biofuel ?

2nd generation EtOH or **methane production :** a **biomass sorghum**



Photosensitivity



What sorghum for what biofuel ?

2

1st generation EtOH or **cogeneration :** a **sweet sorghum** with the following traits:

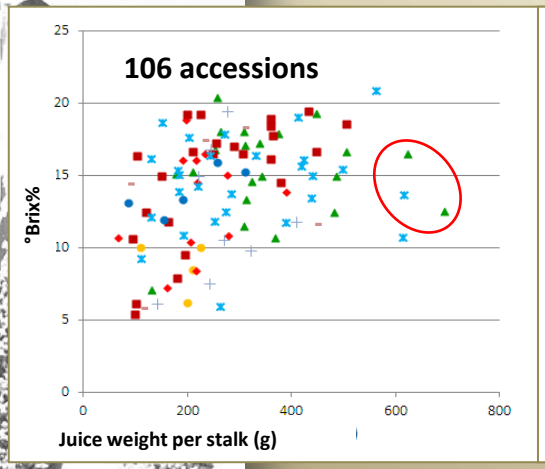
- ✓ **High biomass** production (30-40 TDM ha $^{-1}$) which means a plant height > 3.5-4m
- ✓ high accumulation of **soluble sugars in stalks**, °Brix% of 15 to 20 with 80% of saccharose
- ✓ **juicy** stalks
- ✓ high energetic value of the bagasse for cogeneration which means more fiber with lignin)
- ✓ adaptation to martginal soils (acidity, Al toxicity, P deficiency)
- ✓ adaptation of crop cycles (complementary with sugar cane)

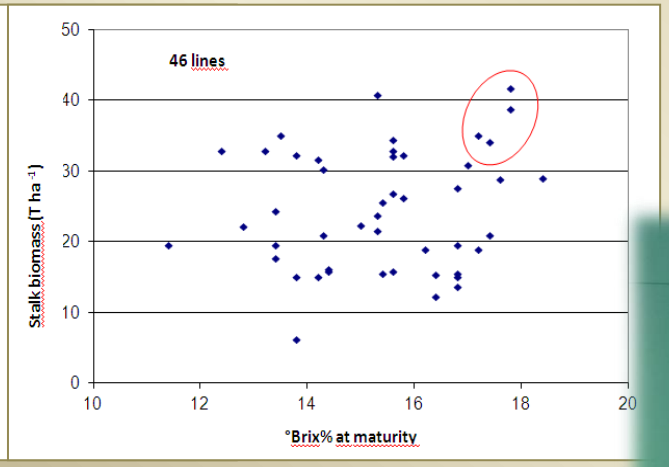
for that purpose, grain production is not wishable

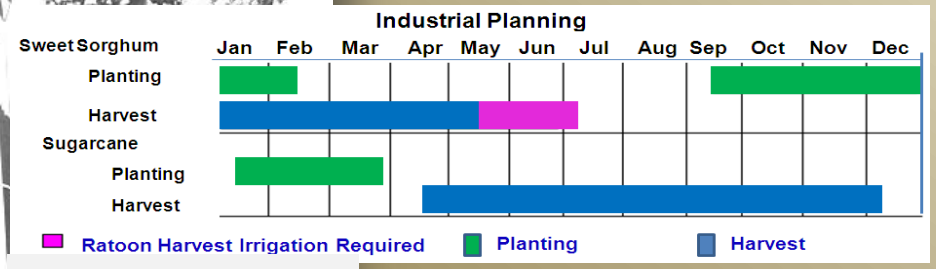
What sorghum for what biofuel ?

2

1st generation EtOH or cogeneration : a sweet sorghum







From R. Schaffert - Embrapa

gene for tolerance to aluminum toxicity : ***Alt$_{SB}$***

Possible combination of
+ °Brix% with juice
+ °Brix% with stalk biomass
+ Al tolerance
+ complementarity sugar cane cycles

What sorghum for what biofuel ?

3

1st generation EtOH combining with **grain** and **fodder**: a sweet sorghum with the following traits:

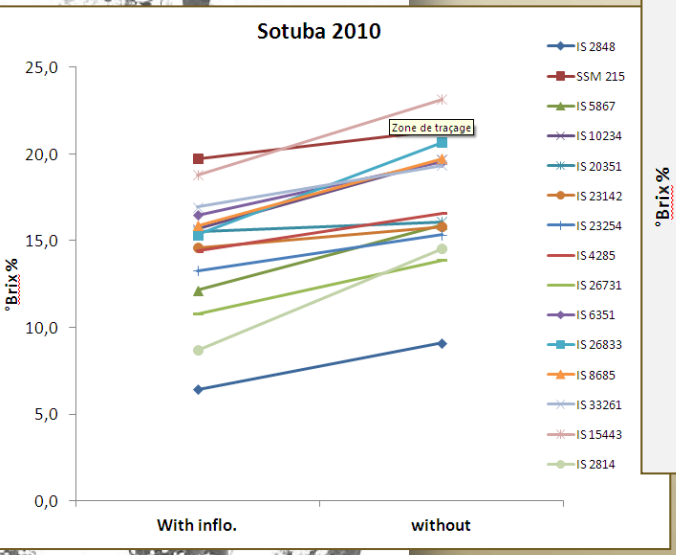
- ✓ **High biomass** production (20-30 TDM ha $^{-1}$) which means a plant height ± 3m and a long cycle (4-5 months)
- ✓ a mean production of **grain** (1.5 to 3 T ha $^{-1}$)
- ✓ high accumulation of **soluble sugars in stalks**, °Brix% of 15 to 20 with 80% of saccharose
- ✓ **juicy** stalks
- ✓ high value of the **bagasse as fodder** which means high digestibility (=*bmr* trait = low lignin content in bagasse)
- ✓ adaptation to **marginal soils** and **rainfall distribution** (stay green, adapted photosensitivity)

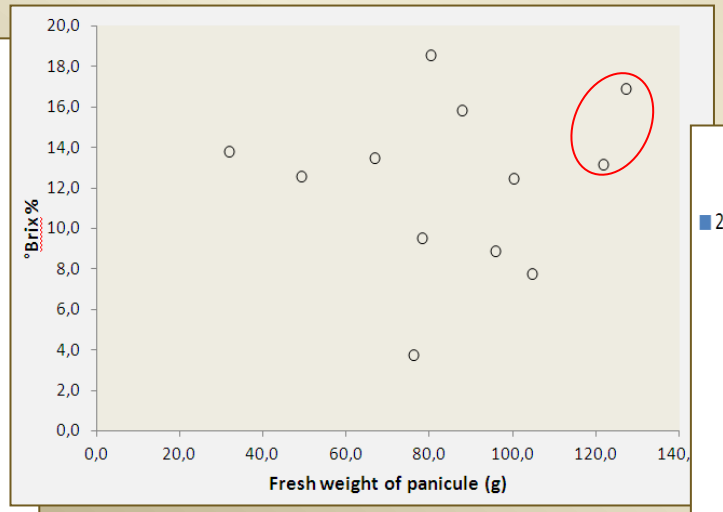
for that purpose, grain production is essential

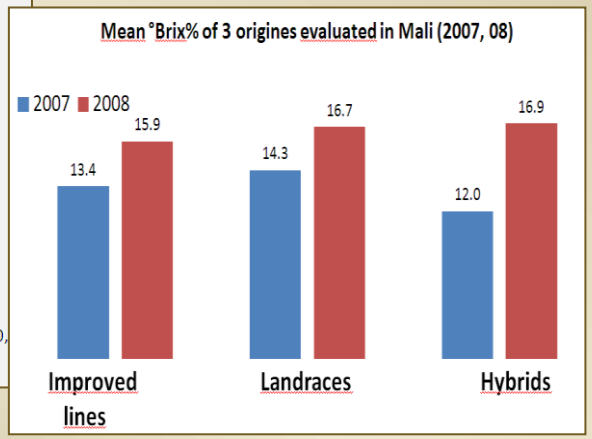
What sorghum for what biofuel ?

3

1st generation EtOH + grain + fodder: a sweet sorghum







95 T FW Biomass + 5 T grain + 7-12% sugar	Almodares et Hatamipour 2011
60 T DW biomass + 4 T grain + °Brix 18	Zhang 2010
20 T DW biomass + 5 T panicule + °Brix% 16 + 12 T juice	Pers. Com. 2011
65 T DW biomass + 2.2 T grain + 18.7 °Brix%	Schaffert 2010
44.8 T FW cane + 4 T grain + 18.4 T juice + 12 °Brix%	S. Rao 2009
…	

There is a competition grain/soluble sugars but not high
There is a great diversity that we have to explore without forgetting landraces

Sweet sorghum : a multi-purpose use

Food

Feed

Fuel

Fertilizer

Fibers

Bioproducts

...











Thank you for your attention

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